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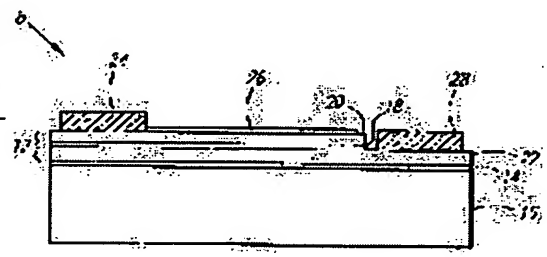
(54) FLUORESCENCE-CONVERTING LIGHT EMITTING DIODE

(57)Abstract:
PROBLEM TO BE SOLVED: To obtain a light emitting device based on a light emitting diode which device can overcome the defect of the conventional light emitting diode.
SOLUTION: There is provided a method for manufacturing the light emitting device, which comprises preparing a light emitting diode that radiates the primary light, and disposing adjacently to the light emitting diode the fluorescent substance, (Sr1-u-v-xMguCavBax)(Ga2-y-zAlyInzS4):Eu2+, that can absorb at least part of the primary light and radiate the secondary light having a wave length longer than that of the primary light. The composition of the fluorescent substance can be selected to determine the wave length of the secondary light. In one embodiment, the light emitting device comprises a fluorescent substance that is dispersed as fluorescent particles in another substance disposed in the circumference of the light emitting diode. In another embodiment, the light emitting device comprises a fluorescent substance that is affixed as a fluorescent film on to at least one surface of the light emitting diode.



3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1]A light emitting diode which emits primary light, and said light emitting diode surface in part at least Weight, Said at least a part of primary light is absorbed, A fluorescent substance of :Eu^{2+} which can emit secondary light which has long wave length from wavelength of said primary light (Ga_{2-y-z}aluminum$_yIn_zS_4$) ($Sr_{l-u-v-x}Mg_uCa_vBa_x$) is included, A light-emitting device characterized by being 0<=u<=1, 0<=v<=1, 0<=x<=1, 0<=(u+v+x) <=1, 0<=y<=2, 0<=z<=2, and 0<=y+z<=2 here.
[Claim 2]The light-emitting device according to claim 1 with which said light emitting diode contains a substance of aluminum$_rIn_sGa_tN$ which is 0<=r<=1, 0<=s<=1, 0<=t<=1, and r+s+t=1.
[Claim 3]The light-emitting device according to claim 1 in which said light emitting diode is a laser diode.
[Claim 4]The light-emitting device according to claim 1 with which said primary light has the wavelength between about 380 to about 500 nanometers.
[Claim 5]The light-emitting device according to claim 1 with which said secondary light has the wavelength between about 490 to about 610 nanometers.
[Claim 6]The light-emitting device according to claim 1 absorbing a necessary part of said primary light so that full power of primary light by which said fluorescent substance is not absorbed may be about 5% or less of the full power of total radiation secondary light.
[Claim 7]The light-emitting device according to claim 1, wherein said fluorescent substance is distributed as a fluorescence particle by another substance arranged around [at least a part of] said light emitting diode.
[Claim 8]The light-emitting device according to claim 7, wherein said fluorescence particle and said another substance are arranged on at least one surface of said light emitting diode.
[Claim 9]The light-emitting device according to claim 7 which is the substance chosen from a group to which said another substance changes from an epoxy resin, acrylic polymer, polycarbonate, silicon polymer, optical glass, and chalcogenide glass.
[Claim 10]The light-emitting device according to claim 7 with which said another substance has a refractive index of about 1.5 or more in wavelength of said primary light.
[Claim 11]The light-emitting device according to claim 7 with which said another substance has a refractive index of about 2.1 or more in wavelength of said primary light.
[Claim 12]The light-emitting device according to claim 7 which adheres to said fluorescent substance as a homogeneous fluorescent film optically on at least one surface of said light emitting diode.
[Claim 13]The light-emitting device according to claim 12 in which said fluorescent film is a thickness of about 2 to about 20 microns.
[Claim 14]The light-emitting device according to claim 12 which adheres in said light emitting diode to said fluorescent film on at least one surface of said board layer including a board layer.
[Claim 15]So that it may be the method of manufacturing a light-emitting device, a light emitting diode which emits primary light may be formed and said fluorescent substance can emit secondary light which absorbs said at least a part of primary light, and has long wave length from wavelength of said primary light, Said light emitting diode surface piles up in part at least, provide a fluorescent substance of :(Ga($Sr_{l-u-v-x}Mg_uCa_vBa_x$) $_{2-y-z}$aluminum$_yIn_zS_4$) Eu^{2+}, and here, A method characterized by what is set to 0<=u<=1, 0<=v<=1, 0<=x<=1, 0<=(u+v+x) <=1, 0<=y<=2, 0<=z<=2, and 0 <=y+z<=2.
[Claim 16]A way according to claim 15 said light emitting diode contains a substance of aluminum$_rIn_sGa_tN$ which is 0<=r<=1, 0<=s<=1, 0<=t<=1, and r+s+t=1.
[Claim 17]A way according to claim 15 said light emitting diode is a laser diode.

[Claim 18]A way according to claim 15 said primary light has the wavelength between about 380 to about 500 nanometers.
[Claim 19]A way according to claim 15 said secondary light has the wavelength between about 490 to about 610 nanometers.
[Claim 20]A method of including further choosing u, v, x, y, and z value, in order to determine wavelength of said secondary light according to claim 15.
[Claim 21]A method of distributing said fluorescent substance as a fluorescence particle in another substance, and including arranging said another substance in at least a part of surroundings of said light emitting diode further according to claim 15.
[Claim 22]A way according to claim 21 said another substance is a substance chosen from a group which comprises an epoxy resin, acrylic polymer, polycarbonate, silicon polymer, optical glass, and chalcogenide glass.
[Claim 23]A way according to claim 21 said another substance has a refractive index of about 1.5 or more in wavelength of said primary light.
[Claim 24]A way according to claim 21 said another substance has a refractive index of about 1.8 or more in wavelength of said primary light.
[Claim 25]A method of including further choosing concentration of said fluorescence particle in said another substance so that said fluorescence particle may absorb a necessary part of said primary light and full power of primary light which is not absorbed may turn into about 5% or less of full power of total radiation secondary light according to claim 21.
[Claim 26]A method of including further choosing concentration of said fluorescence particle in a substance besides the above, in order to adjust the degree of mixed color of said primary light and said secondary light according to claim 21.
[Claim 27]A method of including further adhering said fluorescent substance as a homogeneous fluorescent film optically on at least one surface of said light emitting diode according to claim 15.
[Claim 28]A method of including choosing thickness of said fluorescent film further so that said fluorescent film may absorb a necessary part of said primary light and full power of primary light which is not absorbed may turn into about 5% or less of full power of total radiation secondary light according to claim 27.
[Claim 29]A method of including choosing thickness of said fluorescent film further, in order to adjust a chromaticity of a mixture of said primary light and said secondary light according to claim 27.
[Claim 30]A method of including further annealing said film at temperature of about 500 to about 800 degrees according to claim 27.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]

[Field of the Invention]Generally this invention relates to details more about a light-emitting device at a fluorescence conversion light emitting diode.
[0002]
[Description of the Prior Art]The emission spectrum of a light emitting diode (LED) usually expresses the quite narrow single peak (peak wavelength) of the wavelength decided by the structure of a light emitting diode, and the presentation of the structure material. For example, the emission spectrum of the light emitting diode of an aluminum$_x$In$_y$Ga$_z$N base usually becomes a peak on the wavelength of about 400 (nm) to about 590 nanometers, and the overall width of the 1/2 maximum is usually about 50 nanometers from about 20 nanometers. Similarly, the emission spectrum of the light emitting diode of an aluminum$_x$In$_y$Ga$_z$P base usually becomes a peak on the wavelength of about 580 to about 660 nanometers, and the overall width of the 1/2 maximum is usually about 30 nanometers from about 13 nanometers. in the display of aluminum$_x$In$_y$Ga$_z$N and aluminum$_x$In$_y$Ga$_z$P -- being careful -- it is 0<=x<=1, 0<=y<=1, 0<=z<=1, and x+y+z=1.
[0003]
[Problem(s) to be Solved by the Invention](For example, it characterizes with external quantum efficiency) The light emitting diode of the maximum efficiency which emits light on the wavelength between about 400 to about 660 nanometers, At present, it is a light emitting diode of aluminum$_x$In$_y$Ga$_z$N and an aluminum$_x$In$_y$Ga$_z$P base. However, it depends also for the efficiency of the light emitting diode of which mold to the peak emission wavelength of a light emitting diode strongly. Specifically, the efficiency of the light emitting diode of aluminum$_x$In$_y$Ga$_z$N and an aluminum$_x$In$_y$Ga$_z$P base shows the double width minimum in the peak emission wavelength between about 515 to about 590 nanometers. The sensitivity of human being's eyes includes the spectral range which becomes a peak in it being inconvenient, and this double width minimum has barred attractive application development commercially [other / many of] about the light emitting diode.
[0004]Another fault of the light emitting diode of an aluminum$_x$In$_y$Ga$_z$N base, It is the big blue deviation of luminescence produced with the increase in driving current, and especially this is set to the light emitting diode which has the peak emission wavelength between about 510 to about 590 nanometers. For the driving current modulating method used for adjusting the radiance of a light emitting diode, for example in the object for a display, this blue deviation will have to become very remarkable and must be filled up at the expense of an addition as a result.
[0005]Another fault of the conventional aluminum$_x$In$_y$Ga$_z$N and the light emitting diode of an aluminum$_x$In$_y$Ga$_z$P base, A standard top is under the same manufacturing conditions, and it is in in a standard top, the luminescent characteristic of a light emitting diode changing with wafers, or what was created by the same method changing with the fields on the same wafer. This variability is produced from a small variation in a presentation and thickness of the sensitivity of the luminescent characteristic of a light emitting diode, and the various semiconductor layers which it specifically has, for example in an active region. About the thing of the narrow peak wavelength range (bottle), it is difficult to attain a high production yield as a result of this variability. What is needed is a light-emitting device of the light emitting diode base which conquers these of the conventional light emitting diode, and other faults.
[0006]
[Means for Solving the Problem]A method of manufacturing a light-emitting device is provided with the following.
A light emitting diode which emits primary light is formed.
At least a part of primary light is absorbed, Rather than primary light, long wave length. : (Ga(Sr$_{1-u-v-x}$Mg$_u$Ca$_v$Ba$_x$)$_{2-y-z}$aluminum$_y$In$_z$S$_4$) which can emit secondary light which it has -- approaching this light emitting diode and arranging a fluorescent substance of Eu^{2+}
A value of a presentation of a fluorescent substance, i.e., u, v, x, y, and z can be chosen in order

to decide wavelength of secondary light. one example -- a light emitting diode -- an aluminum$_x$In$_y$Ga$_z$N system — a substance is included. In another example, a light emitting diode is a laser diode.

[0007]In one embodiment, a light emitting diode, A fluorescent substance of :(Ga(Sr$_{l-u-v-x}$Mg$_u$Ca$_v$Ba$_x$) $_{2-y-z}$aluminum$_y$In$_z$S$_4$) Eu^{2+} distributed as a fluorescence particle in another substance arranged around a light emitting diode is included. A substance in which a fluorescence particle and they are distributed can be arranged as a layer on the surface beyond 1 or it of a light emitting diode. Although a substance in which a fluorescence particle was distributed is chosen from a substance containing an epoxy resin, acrylic polymer, polycarbonate, silicon polymer, optical glass, and chalcogenide glass, for example, it is not limited to them. Preferably, a substance in which a fluorescence particle is distributed has a refractive index of about 1.5 or more. A refractive index is about 2.1 or more more preferably. Concentration of a fluorescence particle absorbs specified proportion of primary light, and it can choose it in order for this to adjust the degree of mixed color of primary and secondary light.

[0008]In another embodiment, a light-emitting device, On the surface beyond 1 or it of a light emitting diode, optically as a homogeneous fluorescent film. A fluorescent substance of :Eu^{2+} to which it adheres (Ga$_{2-y-z}$aluminum$_y$In$_z$S$_4$) (Sr$_{l-u-v-x}$Mg$_u$Ca$_v$Ba$_x$) is included. A film of a fluorescent substance of pure (Sr$_{l-u-v-x}$Mg$_u$Ca$_v$Ba$_x$) (Ga$_{2-y-z}$aluminum$_y$In$_z$S$_4$) :Eu^{2+} may be sufficient as a fluorescent film on parenchyma, for example. Thickness of this fluorescent film absorbs specified proportion of primary light, and it can choose it in order for this to adjust the degree of mixed color of primary and secondary light.

[0009]In a spectral range where the conventional aluminum$_x$In$_y$Ga$_z$N and a light emitting diode of an aluminum$_x$In$_y$Ga$_z$P base show the double width minimum in efficiency, a light-emitting device by an embodiment of this invention is an efficient light source, A blue deviation accompanying increase of driving current almost or completely is not shown, and manufacture accompanied by the high quantity of production can be performed in a narrow peak wavelength range.

[0010]

[Embodiment of the Invention]According to the embodiment of this invention, the blue or ultraviolet rays emitted from a diode (primary light) excites the fluorescent substance of IIA-IIIA$_2$ fellows S$_4$ in which Eu^{2+} which answers it and emits a longer (secondary) light of wavelength was doped. Here, "primary light" points out the light emitted by the light emitting diode, and "secondary light" points out the light emitted by the fluorescent substance. Blue or the primary light of ultraviolet rays may have the wavelength of about 320 (nm) to about 510 nanometers, for example. Here, "IIA fellows" and "IIIA fellows" show the column of the periodic table of the elements according to the numbering system of Chemical Abstracts Service.

[0011]The conventional fluorescent substance usually contains the inorganic crystal nature host substance in which lattice ion was replaced by dopant including an ionic lattice. Dopant can be emitted when absorbing an excitation radiation line. Preferably, dopant absorbs an excitation radiation line strongly and changes this energy into ejection radiation efficiently. Regrettably, most conventional fluorescent substances are developed so that it may be used about a cathode-ray tube and a fluorescence beam, and fluorescence is excited by a high energy electron and the ultraviolet radiation by mercury discharge here, respectively (to 254 nanometers). Therefore, most conventional fluorescent substances do not fit excitation by blue or an ultraviolet radiation light emitting diode.

[0012]The compound of IIA-IIIA$_2$ fellows S$_4$ in which Eu[artificers] $^{2+}$ was doped, Specifically 0<=u<=1, 0<=v<=1, 0<=x<=1, 0<=. (u+v+x) The :(Ga(Sr$_{l-u-v-x}$Mg$_u$Ca$_v$Ba$_x$) $_{2-y-z}$aluminum$_y$In$_z$S$_4$) Eu^{2+} substance at the time of being referred to as <=1, 0<=y<=2, 0<=z<=2, and 0 <=y+z<=2, It discovered that it was advantageously employable as a fluorescent substance for changing the blue from a light emitting diode, and ultraviolet radiation into the longer radiation of wavelength.

Some of these substances have so far been studied for the examination of the crystalline field theory about the luminescence dopant of alkaline earth sulfides, for example. Absorption of these substances and some of emission spectra. "For example, Journal of SolidState Chemistry magazine 83 No. 316-323 (1989) by the M.R. dowel loss etc. which are incorporated here as reference Strontium and barium, luminescence of Eu^{2+} in thio gallate", and the system (M=Ca and Sr.) of "Ms-aluminum$_2S_3$ of Material Science and Engineering magazine B14 No. 393-397 (1992) similarly according to KT. Reti etc. Ba) And investigation [of the luminescence attribute of the thio aluminate doped with europium]", Similarly, T.E. Journal by Peters etc. of the Electrochemical. It is reported by "luminescence of thio gallate fluorescent substance Ce^{+3} and Eu^{2+} and the structure special-feature-activity fluorescent substance part 1" in the 230-page February, 1972 item of Society:Solid State Science and Technology. These papers have also reported again the synthetic process in which the substance of :(Ga($Sr_{l-u-v-x}Mg_uCa_vBa_x$) $_{2-y-z}$aluminum$_y$$In_zS_4$) Eu^{2+} is created.

[0013]If drawing 1 is referred to, the excitation spectrum 2 of $SrGa_2S_4$:Eu^{2+} will be prolonged in an ultraviolet-rays region from about 500 nanometers. The excitation spectrum 3 of $CaGa_2S_4$:Eu^{2+} is similarly prolonged in an ultraviolet-rays region from about 530 nanometers. Specifically $SrGa_2S_4$:Eu^{2+}, Strong absorptivity is shown in the range between about 380 nanometers and about 480 nanometers, and $CaGa_2S_4$:Eu^{2+} shows strong absorptivity in the range between about 380 nanometers and about 510 nanometers. Therefore, excitation of $SrGa_2S_4$:Eu^{2+} and $CaGa_2S_4$:Eu^{2+} is possible by the exit light of the light emitting diode of an aluminum$_x$$In_yGa_zN$ base. For example, the emission spectrum 4 of the aluminum$_x$$In_yGa_zN$ base which becomes a peak at nearly 450 nanometers, It overlaps with the excitation spectrum 2 of $SrGa_2S_4$:Eu^{2+}, and the excitation spectrum 3 of $CaGa_2S_4$:Eu^{2+} substantially. As for the emission spectrum 5 of $SrGa_2S_4$:Eu^{2+} and the emission spectrum 6 of $CaGa_2S_4$:Eu^{2+} which are produced as a result, each becomes a peak at about 537 nanometers and about 560 nanometers. The emission spectrum of $SrGa_2S_4$:Eu^{2+}, and the emission spectrum of $CaGa_2S_4$:Eu^{2+}, It is equal to the light emitting diode of the aluminum$_x$$In_yGa_zN$ base where the overall width of the 1/2 maximum is about 50 nanometers, and both eject green.

[0014]($Sr_{l-u-v-x}Mg_uCa_vBa_x$) The optical excitation of the substance of :Eu^{2+}, and radiation (Ga_{2-y-z}aluminum$_y$$In_zS_4$), It generates via optical transition strongly subordinate in the crystal field between an Eu^{2+}4f ground state and a 5-d primary excitation state. Transition produced by this parity has the oscillating intensity by strong absorption, strong radiation, luminescence that shows rapid attenuation, and the high electric doublet which produces high light quantity child efficiency. This substance can attain the inside and external quantum efficiency of not less than about 90%.

[0015]Crystal field dependence of 4f-5d optical transition Barium of periodic table column II-A of strontium (it is shown in drawing 1 like), The deviation of the emission spectrum in $SrGa_2S_4$:Eu^{2+} which has the partial or perfect substitution of the partial or perfect substitution of calcium, magnesium, or another ion and aluminum of the periodic table column IIIA of gallium, indium, or another ion is brought about. The peak wavelength of the emission spectrum in $SrGa_2S_4$:Eu^{2+} specifically, By partial or perfect substitution of magnesium to strontium, to about 510 nanometers (bluish green), from about 537 nanometers (green). And a deviation can be continuously done for about 560 nanometers from about 537 nanometers by partial or perfect substitution of calcium to strontium. The deviation of peak wavelength is possible to about 610 nanometers by partial or perfect substitution of barium to strontium. The peak wavelength of the

emission spectrum of $SrGa_2S_4:Eu^{2+}$, By partial or perfect substitution of aluminum to gallium, to about 490 nanometers (bluish green), from about 537 nanometers. And a deviation can be continuously done for about 610 nanometers from about 537 nanometers by partial substitution (up to 0 to about 50%) of indium to gallium. The peak emission wavelength of the fluorescent substance of $:Eu^{2+}$ used by the embodiment of this invention (Ga_{2-y-z}aluminum$_y In_z S_4$) ($Sr_{l-u-v-x}Mg_u Ca_v Ba_x$) in this way, It can adjust continuously from about 490 nanometers to about 610 nanometers.

[0016]Crystal field dependence of optical transition again, (It is shown in drawing 1 like) The deviation of the absorption spectrum of broader-based $SrGa_2S_4:Eu^{2+}$ which has the partial or perfect substitution of other II-A fellows ion to strontium and the partial or perfect substitution of other III-A fellows ion to gallium is brought about. However, most fluorescent substances of : ($Ga(Sr_{l-u-v-x}Mg_u Ca_v Ba_x)$ $_{2-y-z}$aluminum$_y In_z S_4$) Eu^{2+} in spite of the deviation of an absorption spectrum for example, It is excited by the blue from the light emitting diode of an aluminum$_x In_y Ga_z N$ base, or ultraviolet radiation.

[0017]United States patent 6th to which the embodiment of this invention incorporates the whole here by reference, for example, the light emitting diode of the aluminum$_x In_y Ga_z N$ base currently indicated by No. 133 or 589, And it is transferred to the grantee of this invention and blue like the flip chip of an aluminum$_x In_y Ga_z N$ base or the ultraviolet light radiation diode currently indicated by American patent application serial number 09 which incorporates the whole here by reference / No. 469 or 657 is adopted. The blue and the radio luminescence diode of ultraviolet light based on other material systems like an II-VI compound semiconductor are also employable in the embodiment of this invention.

[0018]If drawing 2 is referred to, the light emitting diode 8 of an aluminum$_x In_y Ga_z N$ base will be used for one embodiment of this invention, for example. The light emitting diode 8 includes the multilayer epitaxial structure 12 which is arranged on the buffer layer 14 and then is arranged on the substrate 16. The substrate 16 can be formed from sapphire (aluminum oxide) or silicon carbide, for example. The epitaxial structure 12 includes the active region 18 arranged between the p type top aluminum$_x In_y Ga_z N$ field 20 and the lower aluminum$_x In_y Ga_z N$ field 22. The aluminum$_x In_y Ga_z N$ field 22 contains a n type and/or the aluminum$_x In_y Ga_z N$ layer which is not doped. The active region 18 contains 1 or the quantum well beyond it formed from an aluminum$_x In_y Ga_z N$ layer. Electric combination of the ohm p contact 24 and the metal layer 26 is mutually carried out to the top aluminum$_x In_y Ga_z N$ field 20. Electric combination of the ohm p contact 28 is carried out to the lower aluminum$_x In_y Ga_z N$ field 22. Pouring of an electron and an electron hole will be made by application of the suitable forward bias to the contacts 24 and 28 in the active region 18. The electron in the active region 18 and the radiation recombination of an electron hole generate light. In one example, the metal layer 26 is translucent to the light emitted by the active region 18. In another example, the metal layer 26 is high-reflected in the light emitted by the active region 18, and the light emitting diode 8 is carried as a flip chip of the contacts 24 and 28 facing submount. Probably, it turns out that the presentation of aluminum$_x In_y Ga_z N$ changes with the various layers and fields of the light emitting diode 8.

[0019]When drawing 3 is referred to, in one embodiment of this invention, the fluorescence conversion light emitting diode 29 contains a light emitting diode like the light emitting diode 8. The light emitting diode 8 is arranged in the reflective cup 30, and this reflective cup again, ($Sr_{l-u-v-x}Mg_u Ca_v Ba_x$) The transparent substance 32 is included on the parenchyma by which the fluorescence particle 34 of $:Eu^{2+}$ was distributed (Ga_{2-y-z}aluminum$_y In_z S_4$). The substance 32 and the fluorescence particle 34 are arranged around the light emitting diode 8. In the operation of the fluorescence conversion light emitting diode 29, at least a part of blue emitted by the light

emitting diode 8 or ultraviolet-rays primary light excites the fluorescence particle 34, and this fluorescence particle 34 answers it and emits secondary light with longer wavelength. The reflective cup 30 reflects and returns an unabsorbed primary light to the fluorescence particle 34, and raises conversion in the secondary light of primary light in this way. The reflective cup 30 forms the optical output of the fluorescence conversion light emitting diode 29 again towards the direction which separates the mixed light of secondary light and an unabsorbed primary light from the light emitting diode 8.

[0020]Specifically the fluorescence particle 34 of $Sr_{l-u-v-x}Mg_uCa_vBa_x(Ga_{2-y-z}$ $aluminum_yIn_zS_4):Eu^{2+}$, It is from about 0.5 micron (micrometer) in diameter to about 10 microns, and is doped by Eu^{2+} by the concentration from about 0.5 atomic ratios to about 6.0 atomic ratios.A fluorescence particle may be compounded by the method explained with d'Abo Ross et al. and tees, or the method obtained from the Phosphor Technologies Limited of State NAZEINGU of Essex of Britain, for example, for example.

[0021]The substance 32 is a transparent substance on parenchyma to the blue of the light emitting diode 8 or the primary radiation of ultraviolet rays, and the secondary radiation of the fluorescence particle 34. Organicity or inorganic matter may be sufficient as the substance 32, for example, it can contain the usual epoxy resin, acrylic polymer, polycarbonate, silicon polymer, optical glass, and chalcogenide glass. If it is a person skilled in the art, the substance 32 and the fluorescence particle 34 will recognize being arranged at the reflective cup 32 by United States patent 5th incorporated here as reference, and the various publicly known methods containing what currently indicated by No. 959 or 316, for example.

[0022]In the embodiment of drawing 3, the fluorescence particle 34 is usually distributed by the substance 32 by about 5 to about 35% of concentration, i.e., the concentration in which the weight of the substance 32 and 100 g of mixtures (g) of the fluorescence particle 34 usually contains about 5 to about 35-g fluorescence particle. It depends for the rate of the primary light changed into secondary light by the fluorescence particle 34 on the concentration of the fluorescence particle of the substance 32, and the quantity of the substance 32 arranged around the light emitting diode 8, and the mixture of the fluorescence particle 34 selectively. For example, the emission spectra 36 and 38 about the two different fluorescence conversion light emitting diodes 29 in which drawing 4 A and drawing 4 B have the same fluorescent substance of $SrGa_2S_4:Eu^{2+}$ in the parenchyma top currently distributed by the epoxy resin, respectively by about 18% and about 36% of the weight of concentration, It is shown, respectively. The emission spectrum in drawing 4 A shows a fluorescent substance radiation peak by about 537 nanometers, and it is not absorbed by the fluorescence particle but it shows a clear peak at about 480 nanometers by it corresponding to the blue primary radiation from the light emitting diode which was not changed. By contrast, it is only that the emission spectrum of drawing 4 B shows the only clear peak by about 537 nanometers.

[0023]Usually, the concentration of the fluorescence particle 34 of the substance 32 is chosen in order to change the rate of a request of primary light into secondary light. For example, in one embodiment the concentration of the fluorescence particle 34, The optical output of the fluorescence conversion light emitting diode 29 (composition of secondary and unabsorbed primary luminous radiation) is chosen so that it may become a chromaticity of a request which is specified by the chromaticity coordinate of Commision Internationale del'Eclairage (CIE) for example. If it is a person skilled in the art, the concentration of the fluorescence particle 34 corresponding to [it is suitable to change the rate of a request of primary light, or] the chromaticity of a request of the optical output of the fluorescence conversion light emitting diode 29, What it can opt for experientially will be recognized by measuring the emission spectrum corresponding to the examination concentration of a fluorescence particle, and also adjusting concentration, if required. In one existing example, the concentration of a fluorescence particle is chosen so that about 5% or less of the optical outputs (light) emitted by the fluorescence conversion light emitting diode 29 may serve as primary radiation from the light emitting diode 8. In another example, about 1% or less of the optical outputs (light) emitted by

the fluorescence conversion light emitting diode 29 are primary radiation.
[0024]Primary light depends on the refractive index of the substance 32 for the efficiency changed into secondary light by the fluorescence particle 34 selectively. Concretely, when the refractive index of the substance 32 is below the refractive index of a fluorescence particle, a part of primary light is diffused so that it may return to the light emitting diode 8 by the fluorescence particle 34, and resorption of it is carried out without being changed into secondary light. The refractive index of the fluorescence particle 34 is usually about 2.1 to about 2.4. Therefore, in one example, as for the substance 32, the refractive index of about 1.5 or more and the thing which has a refractive index of about 2.1 or more preferably are chosen. In this example, the substance 32 is chalcogenide glass, for example.
[0025]The secondary light element of the emission spectrum of the fluorescence conversion light emitting diode 29, ****: $(Ga(Sr_{l-u-v-x}Mg_uCa_vBa_x)_{2-y-z}aluminum_yIn_zS_4)$ The presentation of the fluorescence particle 34 of Eu^{2+} can be adjusted by changing. In one embodiment, the fluorescence particle 34 of :$(Ga(Sr_{l-u-v-x}Mg_uCa_vBa_x)_{2-y-z}aluminum_yIn_zS_4)$ Eu^{2+}, The optical output of the fluorescence conversion light emitting diode 29 (composition of secondary and unabsorbed primary luminous radiation) is chosen so that it may become a chromaticity of the request specified by the chromaticity coordinate of Commision Internationalede'Eclairage (CIE) for example. If it is a person skilled in the art, the presentation of the fluorescence particle 34 corresponding to the chromaticity of a request of the optical output of the fluorescence conversion light emitting diode 29 will recognize that it is dependent on the luminescent characteristic of the light emitting diode 8. A suitable presentation is experientially determined by measuring the emission spectrum of the fluorescence conversion light emitting diode 29 for the experimental presentation of the fluorescence particle 34, and also adjusting this experimental presentation, if required.
[0026]In one embodiment, the presentation of the fluorescence particle 34 is chosen and the fluorescence conversion light emitting diode 29 which has the optical output which had a desired chromaticity mostly is provided. Next, after a presentation is chosen, the concentration of the fluorescence particle 34 changes the rate of unabsorbed primary radiation, and is adjusted for fine adjustment of a chromaticity. A presentation and concentration of a fluorescence particle can perform repetitive change, for example until a desired chromaticity is attained. When drawing 5 is referred to, in another embodiment, the fluorescence conversion light emitting diode 35 contains the light emitting diode 8 which adhered to the fluorescence layer 37 containing the above-mentioned fluorescence particle 34. In some of embodiments, the fluorescence layer 37 contains the transparent substance 32 on the parenchyma by which the fluorescence particle 34 was distributed. In other embodiments, the fluorescence layer 37 does not contain the transparent substance 32. Although it indicates that the upper part and the flank of the light emitting diode 8 adhered to the fluorescence layer 37, only the upper surface of the light emitting diode 8 adheres to the fluorescence layer 37 in other examples, for example. Although the fluorescence conversion light emitting diode 35 contains the reflective cup 30 in drawing 5, the reflective cup 30 is not included in other examples.
[0027]The method to which the fluorescence layer 37 is made to adhere includes spraying, screen-stencil, electrophoresis, the immersion to slurry, etc., for example. In one example, the fluorescence layer 37 is a conformal fluorescence layer formed by the stencil process currently explained in American patent application serial number 09th which it was transferred to the grantee of this invention and incorporated here by considering the whole as reference / No. 688 or 053. The concentration of the fluorescence particle 34 of the fluorescence layer 37 and a presentation change the request rate of primary light into secondary light, and they can adjust it in order to generate the optical output of a desired chromaticity by the same method as what was explained above in relation to the fluorescence conversion light emitting diode 29.
[0028]The fluorescence conversion light emitting diode by the embodiment of this invention has some advantages as compared with the conventional $aluminum_xIn_yGa_zN$ and the light emitting diode of an $aluminum_xIn_yGa_zP$ base. Specifically the fluorescence conversion light emitting diode

of the embodiment of this invention. The conventional aluminum$_x$In$_y$Ga$_z$N and the light emitting diode of an aluminum$_x$In$_y$Ga$_z$P base are the efficient light sources in the range of about 515 to about 590 nanometers which shows the double width minimum in efficiency. The fluorescence conversion light emitting diode of the embodiment of this invention from which the real portion of primary radiation is changed into secondary radiation almost or completely does not show a blue deviation in the radiation accompanied by the exciting current which increases compared with the conventional aluminum$_x$In$_y$Ga$_z$N light emitting diode. In addition, the fluorescence conversion light emitting diode by the embodiment of this invention, In the peak in which the wavelength range is narrower than the conventional aluminum$_x$In$_y$Ga$_z$N and the light emitting diode of an aluminum$_x$In$_y$Ga$_z$P base, manufacture is possible in it being also at a high production yield, And the standard top is accompanied by change of the luminescent characteristic with the same conventional light emitting diode. The secondary radiation of the fluorescence conversion light emitting diode by the embodiment of this invention depends these two advantages on sensitivity being low to change of the peak wavelength of primary radiation.

[0029]Since the size of the above-mentioned fluorescence particle 34 is a grade of the visible wavelength of light, the fluorescence particle of the fluorescence layer 37 usually scatters primary and secondary light which were emitted by the fluorescence conversion light emitting diodes 29 and 35. Therefore, the fluorescence layer 37 is heterogeneity optically, namely, usually scatters light. The homogeneous nature (it is not dispersion-on parenchyma nature) layer of a fluorescence inclusion is optically called a "fluorescent film" here. This fluorescent film contains on parenchyma the film of a pure fluorescent substance, and the film which has a fluorescence particle very smaller than the visible wavelength of the light distributed in the transparent substance on parenchyma, for example. A fluorescent film is incorporable into a fluorescence conversion light emitting diode. When drawing 6 is referred to, in another embodiment of this invention, for example the fluorescence conversion light emitting diode 40, A conventional light emitting diode like the light emitting diode 8, And on the parenchyma to which it adhered on the substrate 16 of the light emitting diode 8. [pure] $(Sr_{l-u-v-x}Mg_uCa_vBa_x)$ The thin fluorescent film 42 of the fluorescent substance of :Eu^{2+} is included (Ga$_{2-y-z}$aluminum$_y$In$_z$S$_4$). The same reference number in various figures expresses the identical parts of various embodiments.

[0030]In the operation of the fluorescence conversion light emitting diode 40, at least a part of blue emitted by the active region 18 of the light emitting diode 8 or ultraviolet-rays primary light enters into the fluorescent film 42, it excites this, and this film answers and emits a longer secondary light of wavelength. The optical output of the fluorescence conversion light emitting diode 40 contains the primary light which is not absorbed [to which it transfers with the secondary light and the fluorescent film 42 which are emitted by the fluorescent film 42]. In one example, the light emitting diode 8 is a flip chip light emitting diode, and the metal layer 26 has advanced reflexibility to the light emitted by the active region 18, therefore it increases the quantity of the incidence primary light to the fluorescent film 42.

[0031]In one example, it adheres to the fluorescent film 42 on the substrate 16 in advance of logging to an individual light emitting diode like the light emitting diode 8 from the wafer of a light emitting diode. Preferably, it adheres to the fluorescent film 42 on the substrate 16 after the contacts 24 and 28 after growth of the epitaxial structure 12, and adhesion of the metal layer 26. However, in order to avoid that the epitaxial structure 12 is damaged between the adhesion processes of a fluorescent substance depending on the case, in advance of growth of the epitaxial structure 12, it is necessary [it] on the substrate 16 to adhere the fluorescent film 42.

[0032]In the embodiment of this invention, it may adhere to the fluorescent film 42 on the substrate 16 by the conventional method used, for example in order to make a thin fluorescent film adhere in the industry of a thin film electroluminescence display. Such common knowledge and the conventional method have electron beam evaporation, thermal evaporation, radio frequency sputtering (rf sputtering), reactant radio frequency rf magnetron sputtering, and metal

organic chemistry vacuum evaporation (MOCVD), for example. If it is a person skilled in the art, it will recognize that it is improvable about the presentation of the fluorescent film 42, and the homogeneity of thickness by, for example, making eccentric circular rotate the wafer of the light emitting diode which adheres to the film 42 in an adhesion step.
[0033]In one embodiment, the fluorescent film 42, Request: $(Ga(Sr_{I-u-v-x}Mg_uCa_vBa_x)_{2-y-z}aluminum_yIn_zS_4)$ It adheres on the substrate 16 by the conventional rf sputtering about the fluorescent substance of Eu^{2+}. End with selection $(Ga_{2-y-z}aluminum_yIn_zS_4)$. $(Sr_{I-u-v-x}Mg_uCa_vBa_x)$: the fluorescent substance of Eu^{2+}, It specifically has a little larger diameter than the wafer of a light emitting diode, and is pressed fit in the target usually located in the place of about 5 to about 10 cm from the substrate 16, and sputtering is carried out on the base 16 in the atmosphere containing argon.
[0034]In another embodiment, the fluorescent film 42, Applied PhysicsLetters No. 63 which incorporated the whole here, 1954-1956. "IIA-III_2 fellows S_4 the presentation of 3 yuan by P. Vena Rawl cited in (1993), etc. : with the conventional reactant rf magnetron sputtering method which is indicated to new host matrix" for a full color thin film film electroluminescence display. It adheres on the substrate 16. In this embodiment, a sputtering target, : $(Ga(Sr_{I-u-v-x}Mg_uCa_vBa_x)_{2-y-z}aluminum_yIn_zS_4)$ of a request in an adhesion process — it is created from the mixture of some precursor powder in which the fluorescent substance of Eu^{2+} is compounded. For example, in one example the fluorescent film 42 of $SrGa_2S_4:Eu^{2+}$, Growth is made on the substrate 16 by the conventional-type rf magnetron sputtering of the target created from the mixture of SrS chosen in order that three precursor portions may offer a desired fluorescence presentation, Ga_2S_3, and EuS. In this embodiment, adhesion is usually generated in the atmosphere containing argon gas and about 1-mol % to about 3-mol% of H_2S. In one example, the fluorescent film 42 is annealed at the temperature of about 500 to about 800 ** after adhesion by rf sputtering or reactant rf magnetron sputtering, for example. An annealing process usually improves the crystallinity of the fluorescent film 42.
[0035]If it is a person skilled in the art, the adhesion step will usually be able to recognize that regulation is possible, in order to usually control the thickness of the fluorescent film 42 from about 2 microns to about 20 microns. The thickness of the fluorescent film 42 can be chosen in order to change the rate of a request of primary light into secondary light. In one example, the thickness of the fluorescent film 42 is chosen so that about 5% or less of the optical power (light) emitted by the fluorescence conversion light emitting diode 40 may be the primary radiation from the light emitting diode 8. In another example, about 1% or less of the optical power (light) emitted by the fluorescence conversion light emitting diode 40 is primary radiation.
[0036]The secondary light component of the emission spectrum of the fluorescence conversion light emitting diode 40, Fluorescent film: $(Ga(Sr_{I-u-v-x}Mg_uCa_vBa_x)_{2-y-z}aluminum_yIn_zS_4)$ The presentation of the substance of Eu^{2+} can be adjusted by changing. In one embodiment, a presentation and thickness of the fluorescent film 42 are chosen so that the optical power (composition of secondary and an unabsorbed primary light) of the fluorescence conversion light emitting diode 40 may serve as a desired chromaticity.
[0037]Although drawing 6 shows the fluorescent film 42 to which it adheres on the substrate 12 of the light emitting diode 8, in other embodiments, another portion of the light emitting diode 8 adheres to a fluorescent film. For example, in drawing 7 the fluorescence conversion light emitting diode 44, The fluorescent film 46 of :Eu^{2+} to which it adheres on the metal layer 26 with this translucent example $(Ga_{2-y-z}aluminum_yIn_zS_4)$ $(Sr_{I-u-v-x}Mg_uCa_vBa_x)$ is included. In another example, the metal layer 26 does not exist in the fluorescence conversion light emitting diode 44, but the fluorescent film 46 is arranged on the top $aluminum_xIn_yGa_zN$ field 20, for example.
[0038]In another embodiment, the wafer of a light emitting diode is used as an item in advance of

adhesion of a fluorescent film. Therefore, the fluorescent film can adhere to a light emitting diode die flank. Like the metallic mold upper part of a light emitting diode, since the primary light which leaks adhesion of the fluorescent film to a flank via the flank of a light emitting diode die is changed by the fluorescent film, the efficiency from which primary light is changed into secondary light increases. For example, when drawing 8 is referred to, the fluorescence conversion light emitting diode 48 contains the fluorescent film 50 to which it adhered on the upper surface of the light emitting diode 8 and the light emitting diode 8, and a part surface. In the example of drawing 8, the fluorescence conversion light emitting diode 48 is carried by the solder lump 54 as a flip chip on the submount 52.

[0039]The fluorescence conversion light emitting diodes 44 and 48 operate like the above-mentioned fluorescence conversion light emitting diode 40. The optical power of the fluorescence conversion light emitting diode 44 contains the secondary light emitted by the fluorescent film 46 and the primary light which is not absorbed [which is emitted by the fluorescent film 46]. The optical power of the fluorescence conversion light emitting diode 48 contains the secondary light emitted by the fluorescent film 50 and the primary light which is not absorbed [which is emitted by the fluorescent film 50]. The thickness of the fluorescent films 46 and 50 and a presentation change the rate of a request of primary light into secondary light, and by the same method as the above-mentioned thing about the fluorescence conversion light emitting diode 40, in order to generate the optical output of a desired chromaticity, adjustment of them is possible.

[0040]The fluorescence conversion light emitting diode containing the fluorescent film of $:Eu^{2+}$ in the embodiment of this invention $(Sr_{l-u-v-x}Mg_uCa_vBa_x)$ $(Ga_{2-y-z}$aluminum$_yIn_zS_4)$ again. The light scattering (for example, it distributed in another substance) fluorescence particle of $:Eu^{2+}$ in this invention $(Sr_{l-u-v-x}Mg_uCa_vBa_x)$ $(Ga_{2-y-z}$aluminum$_yIn_zS_4)$. An above-mentioned advantage is provided also about the fluorescence conversion light emitting diode to adopt. Although the embodiment with specific this invention is indicated, this invention includes all the change and corrections in a claim. For example, the fluorescence conversion light emitting diode by this invention contains the laser diode of a semiconductor. The fluorescence conversion light emitting diode by this invention can contain other layers and substrates which are not indicated in a figure like a reflective metal layer, the layer contained in a distribution Bragg reflection machine, and the layer contained in an optical interference filter, for example.

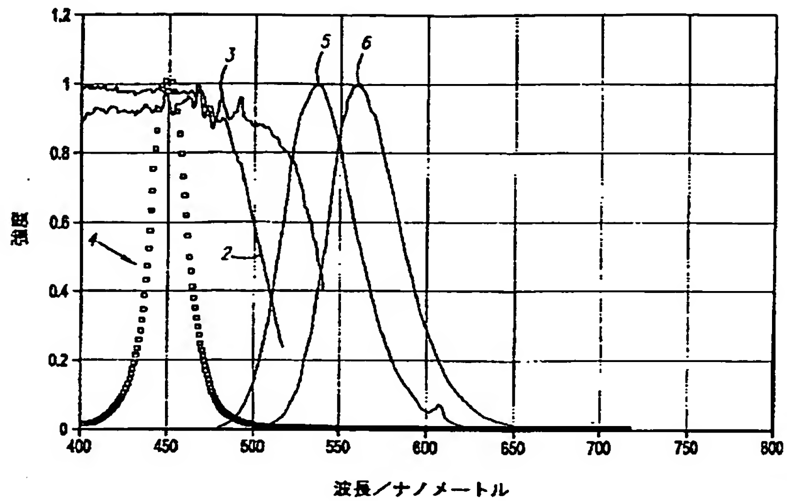
DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]Duplication of excitation and the emission spectrum of excitation and the emission spectrum of $SrGa_2S_4:Eu^{2+}$, and $CaGa_2S_4:Eu^{2+}$, and the emission spectrum of an aluminum$_xIn_yGa_zN$ base is shown.

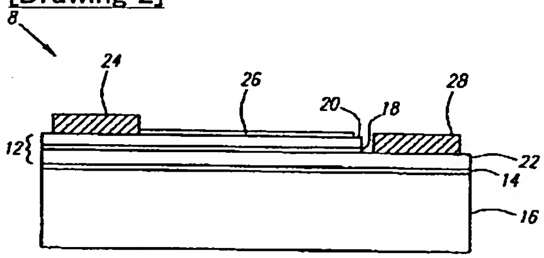
[Drawing 2]It is a schematic illustration of the light emitting diode adopted in the embodiment of this invention.
[Drawing 3]It is a schematic illustration of the fluorescence conversion light emitting diode containing the fluorescence particle in the embodiment of this invention.
[Drawing 4 A] The emission spectrum of the fluorescence conversion light emitting diode containing the fluorescence particle in the embodiment of this invention is shown.
[Drawing 4 B] The emission spectrum of the fluorescence conversion light emitting diode containing the fluorescence particle in the embodiment of this invention is shown.
[Drawing 5]It is a schematic illustration of the fluorescence conversion light emitting diode containing the fluorescence particle in another embodiment of this invention.
[Drawing 6]It is a schematic illustration of the fluorescence conversion light emitting diode containing the fluorescent film in another embodiment of this invention.
[Drawing 7]It is a schematic illustration of the fluorescence conversion light emitting diode containing the fluorescent film in another embodiment of this invention.
[Drawing 8]It is a schematic illustration of the fluorescence conversion light emitting diode containing the fluorescent film in another embodiment of this invention.
[Description of Notations]
8 Light emitting diode
12 Epitaxial structure
14 Buffer layer
16 Substrate
18 Active region
20 Top $\mathrm{aluminum}_x\mathrm{In}_y\mathrm{Ga}_z\mathrm{N}$ field
22 Lower $\mathrm{aluminum}_x\mathrm{In}_y\mathrm{Ga}_z\mathrm{N}$ field
24 Ohm p contact
26 Metal layer
28 Contact
29 Fluorescence conversion light emitting diode
30 Reflective cup
32 Transparent substance
34 Fluorescence particle

DRAWINGS

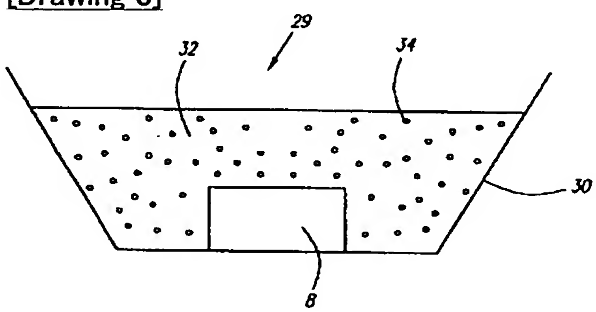
[Drawing 1]



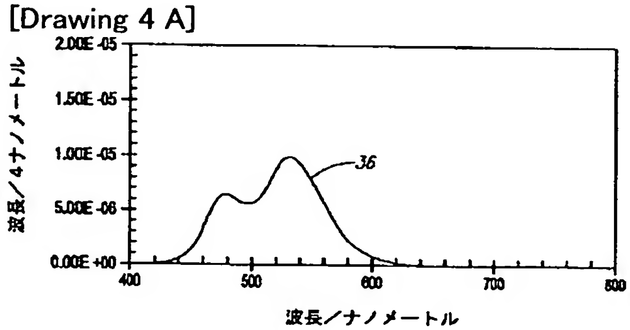
[Drawing 2]



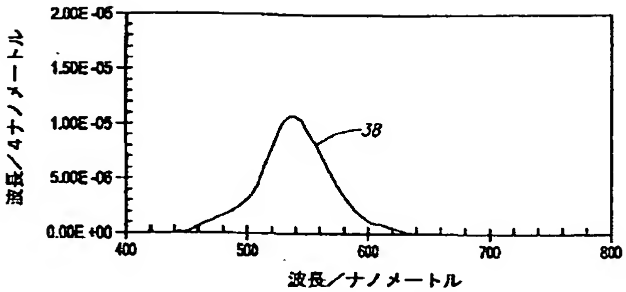
[Drawing 3]



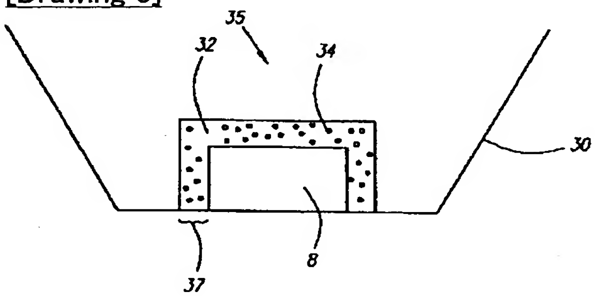
[Drawing 4 A]



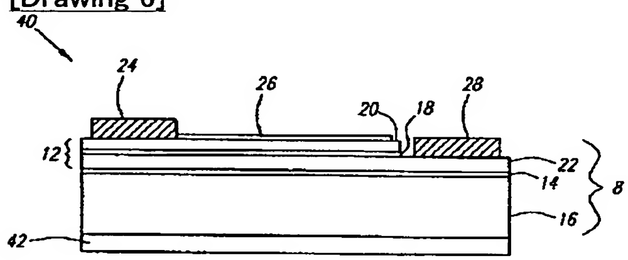
[Drawing 4 B]



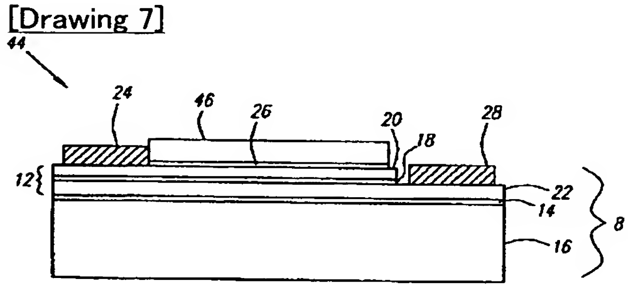
[Drawing 5]



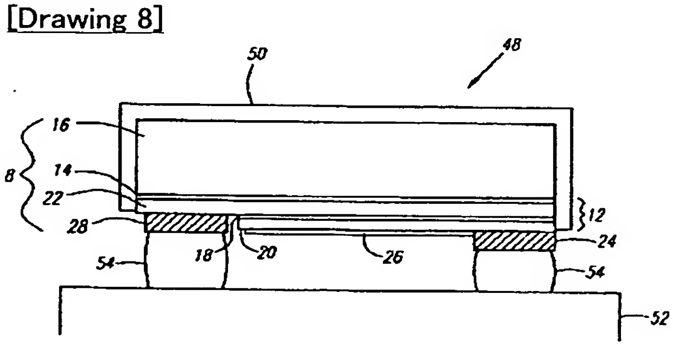
[Drawing 6]



[Drawing 7]



[Drawing 8]



[Translation done.]